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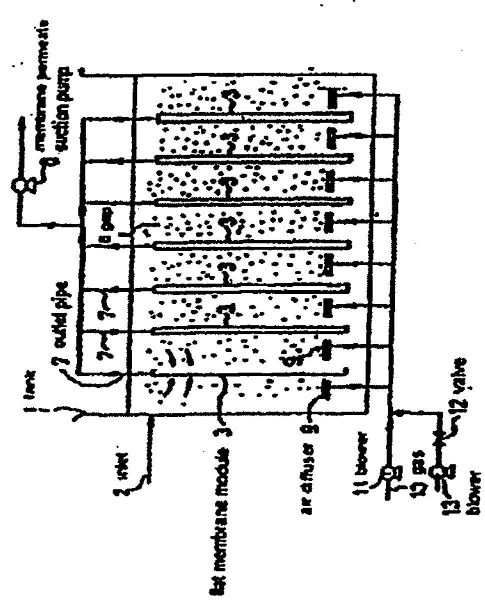
(71) Applicant: 000000402
Ebara Infilco Co., Ltd
1-6-27 Kohnan, Minato-ku, Tokyo-to
(71) Applicant: 000140100
Ebara Research Co., Ltd
4-2-1 Hon-Fujisawa, Fujisawa-shi, Kanagawa-ken
(72) Inventor: KATAOKA, Katsuyuki
Ebara Research Co., Ltd
4-2-1 Moto-Fujisawa, Fujisawa-shi, Kanagawa-ken
(74) Agent: Patent Attorney, HAGINO, Taira
Three others

(54) [Title of the Invention] Membrane Separation Device

(57) [Abstract]

[Object] An object of the present invention is to provide a membrane separation device that can maintain low filtration resistance over a long period of time and that is maintenance free.

[Constitution] The present invention comprises a flat membrane module 3, which is a filter body comprising a spacer 4, and a flat separation membrane that is a UF or MF membrane 5; a tank 1 in which no less than one said flat membrane module 3 is disposed, and which receives a liquid suspension; and a diffuser member 9 of a diffusion device disposed below said flat membrane module 3, or below and to one side of said filter body; an intermittently greater flow of diffused gas from diffusion device per unit of time is established by a blower 11, a blower 13, and a valve 12, and the membrane surface is maintained clean by the action of the liquid suspension generated by the gas 10.



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[Claims]

[Claim 1] A membrane separation device characterized in that this comprises: a filter body comprising a spacer and a flat separation membrane; a tank in which no less than one said filter body is disposed, and which receives a liquid suspension; and a diffusion device having a diffuser member disposed below said filter body, or below and to one side of said filter body, [the membrane separation device] being provided with means for establishing an intermittently greater flow of diffused gas from said diffusion device per unit of time.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] The present invention relates to a membrane separation device capable of providing simple and effective membrane separation of various freely selected suspensions (for example, suspensions of microbiological particles, inorganic particles, and the like), so as to produce a clarified separated liquid.

[0002]

[Prior Art] Conventionally, devices are known wherein a permeate is produced by immersing a hollow-fiber membrane bundle module in an aeration tank (see FIG. 4).

[0003] The device shown in FIG. 4 is such that a hollow-fiber membrane module 22 is immersed in an aeration tank 21; air 24 is supplied from an air diffusion pipe 23 so as to maintain growth of microorganisms by keeping the interior of the tank aerobic while maintaining the filter function of the hollow-fiber membrane; a suction pump 25 is used to obtain permeate 26 from the suspension within the tank which has been microbiologically processed.

[0004] However, when the present inventors did additional tests on this prior art, they found the following serious disadvantages and judged the practicality thereof to be inferior. That is to say, the device shown in FIG. 4 has the following disadvantages.

[0005] (1) SS particles, such as activated sludge or fibrous components, get into the hollow-fiber membrane bundles and adhere or become affixed thereto, causing the filtration resistance to rise sharply. (2) Washing away SS components which have gotten into the interior of the hollow-fiber membrane bundles is extremely difficult; it is not possible to wash away the adherent sludge and fibrous components without removing the hollow-fiber membrane module, undoing it, and spraying it with high-pressure water. This is extremely labor-intensive, and it is practically impossible to implement these operations.

[0006]

[Problems to Be Solved by the Invention] The present invention is directed at completely solving the major problems of the conventional devices described above; an object thereof is to provide a novel technology which can maintain low filtration resistance over a long period of time, and which is maintenance-free.

[0007]

[Means for Solving the Problems] In order that the present invention solve the problems of the prior art, various studies were conducted, and as a result, it was discovered that the conventional problems could be solved by the following means, and [in this manner] the present invention was completed.

[0008] That is to say, the present invention is a membrane separation device characterized in that this comprises: a filter body comprising a spacer and a flat separation membrane, a tank in which no less than one said filter body is disposed, and which receives a liquid suspension; and a diffusion device having a diffuser member disposed below said filter body, or below and to one side of said filter body, [the membrane separation device] being provided with means for establishing an intermittently greater flow of diffused gas from said diffusion device per unit of time.

[0009] The following are novel ideas of the present invention. (1) The use of hollow-fiber membranes is abandoned; a filter body is used having a flat separation membrane wherein the shape makes it impossible for suspended solids to become trapped at the interior of bundles.

[0010] Conventionally, methods wherein flat separation membranes were provided in filter presses and dehydrator structures were known, but the idea of immersing these in an aeration tank as part of a method such as that of the present invention has never before existed.

[0011] (2) It was discovered that it was possible to effectively prevent membrane soiling by intermittently increasing and decreasing the amount of diffused gas so as to create a disturbance at the membrane surface. The filter body used in the present invention has a filter member comprising at least a spacer and a flat separation filter. There are no particular restrictions on the construction of this filter member, so long as the construction of the filter member functions so that a suspension is filtered at least at the exterior of a flat separation membrane so that the filtrate moves to the interior of this membrane, and this is further provided with means for removing the filtrate that has been moved. However, the exterior shape of the filter member is preferably such that, when the filter body is disposed within the tank, the entire surface of the flat separation membrane can easily be contacted by bubbles supplied from the diffusion device and by the currents caused by the bubbles.

[0012] The exterior surface of this filter member is formed as a flat separation membrane, but it is not absolutely necessary that the entire exterior surface be formed as a flat separation membrane; this can be formed locally on a suitable desired surface region.

[0013] Furthermore, so long as the form of the exterior surface of the flat separation membrane satisfies the aforementioned conditions, there are no particular restrictions thereon; this is not limited to flat surfaces; and freely chosen curved surfaces are encompassed thereby. So long as the spacer functions at least to support the flat separation membrane while maintaining a space which allows the filtrate to move to the interior, the construction thereof may be freely chosen, and there are no particular restrictions thereon. Furthermore, means for removing the filtrate which has moved to the interior, such as an outlet pipe, can be provided.

[0014] The material from which the spacer is constructed and the specific shape of the construction may be freely chosen; this can be a simple body with a solid interior or a simple body with a hollow interior, or a frame, or a combination of these. Examples include a frame, a simple plate with a solid interior, a plate provided with a hollow interior, a lattice, etc. In terms of the construction material, a porous material having a filter function is particularly preferable, and in terms of the shape, a plate is particularly preferable.

[0015] In terms of the means for supporting the flat separation membrane on the spacer, adhesives, nuts and bolts, magnets, and the like can be used. Accordingly, the external shape of the filter member of the filter body can be freely determined according to the shape of the spacer and the method of holding the flat separation membrane against the spacer, examples include plates, rods, inverted cones, and the like. In the present invention, plates are particularly preferred, and those wherein a flat separation membrane is formed on both sides are preferred

[0016] There are no particular restrictions on the material for the flat separation membrane.

so long as this can produce a clarified filtrate; well-known ultrafiltration membranes and microfiltration membranes can be used, and the pore size of the membrane may be freely chosen as suitable according to the objective.

[0017] The total surface area of the flat separation membrane for one of these filter bodies is normally chosen from within the range of 4-20 m². The filter body is disposed within the filter device of the present invention, but there are no particular restrictions on the position at which this is disposed or the like; it is preferable that this be positioned so that the flat separation membrane is readily impacted by the bubbles and/or the currents created by the bubbles from the diffusion device, which is also installed within the filter device. In particular, if a plurality of filter bodies are installed, it is preferable that the flat separation membrane surfaces of the filter bodies be parallel to the perpendicular direction, and that a space be suitably provided between each of the flat separation membranes; meanwhile, it is preferable that the diffusion device be installed below the filter body, or below the filter body and to one side, for example, at the bottom of the gap between the filter bodies.

[0018] The diffusion device used in the present invention has a basic structure comprising a blower, a conduit, and a diffuser member, but commonly used well-known devices can be used, and while there are no particular restrictions on the structure thereof, pipes and plates are generally used as the diffuser member.

[0019] The present invention maintains the flat separation membrane clean by means of the gas diffused from the diffusion device, but there are no particular restrictions on the method of supplying this diffused gas to the interior of the tank; the settings for the amount supplied, the supply time, the stop time, and the like can be suitably chosen according to the type of suspension, the type of filter body, the standards for the filtrate, and the like.

[0020] In particular, the present invention is characterized in that the membrane surface can be maintained at a greater level of cleanliness by intermittently establishing a high flow rate of diffused gas per unit of time. In this case, it is particularly preferable that the period of time for which the high flow rate is established (Gt) is shorter than the other period of time (Ct). The amount supplied per unit of time in the Gt time is greater than that in the Ct time, and each of these amounts is normally maintained at a constant level over time, but increasing or decreasing this or stopping the supply in either of the time periods is acceptable. Next, if a plurality of diffusion pipes are used, this may be set up so that each of the diffusion pipes is supplied independently, or the diffusion pipes may be connected and supplied together. The means used for these setups may be freely chosen, and these may be automatic or manual; examples include control of the blower itself or combinations of a blower and a valve, or the like.

[0021] Furthermore, the type of diffused gas may be suitably chosen according to the properties of the suspension used in the present invention; in the case of an aerobic biological processing liquid, gasses containing oxygen, such as air, are commonly used; in the case of an anaerobic biological processing liquid, nitrogen gas may be used. Suspensions such as these processing liquids may be introduced from the exterior or may be processed within the device of the present invention from the beginning. In other words, it is clear that, in addition to membrane separation functions, this invention may have other processing functions for polluted water and the like.

[0022] While the filtration method used in the present invention is a method that moves filtrate from the exterior of the flat separation membrane, which is to say, from the side in contact with the suspension, to the interior of the membrane, freely chosen filter pressure generation means may be used. For example, a negative pressure may be generated within the filter body by means of a pump, the tank may be sealed and the interior of the tank may be positively pressurized, a siphon may be used, etc.

[0023] When a plurality of filter bodies are provided, the filtrate recovery mechanism may be such that this is performed separately for each filter body, or this may be performed with the filter bodies connected. For example, methods include those wherein a filtrate outlet pipe is provided at each spacer, these are connected, and suction filtration is performed by means of a pump.

[0024]

[Embodiments]

In the following, the operation of the present invention and one embodiment thereof are described with reference to FIG. 1. In FIG. 1, 1 is a tank filled with a freely chosen suspension, and 2 is a suspension inlet.

[0025] The basic construction of the membrane separation device of the present invention comprises a tank 1, a flat membrane module 3 which is the filter body, and a diffusion device 7 [sic]. Within the tank 1, a plurality of flat membrane modules 3, wherein a flat UF or MF membrane 5 is provided on both sides of a planar porous body spacer 4, as shown in FIG. 2, is immersed and disposed parallel to the perpendicular direction with gaps 6 therebetween.

[0026] Membrane permeate outlet pipes 7 are provided at each of the filter modules 3. The outlet pipe 5 [sic] is connected to a membrane permeate suction pump 8. Diffuser members 9, made from a diffusing pipe or a diffusing plate, are provided at the bottoms of the flat membrane modules 3; air or another gas 10 is diffused by means of a blower 11. If methane fermentation bacteria, or such anaerobic microorganisms, are to be membrane separated, a gas not containing oxygen, such as nitrogen gas or methane gas, is used as the gas 10.

[0027] In the present invention, the idea of intermittently increasing the amount of gas 10 blown is important; membrane soiling can be prevented more effectively than in the case where gas is diffused at a constant rate; and, it has been experimentally confirmed that this allows for maintenance of a high membrane flux for a long period of time.

[0028] The means for intermittently increasing the rate of flow of the gas 10 are simple and any means can be used but, in the example of FIG. 1, a method is adopted wherein a blower 13 is provided, and a valve 12 is intermittently opened and closed.

[0029] In terms of why soiling of the membrane can be effectively prevented by intermittently increasing the rate at which the gas 10 is diffused, that mechanism is not understood in detail at the present time, but it is presumed to be as follows.

[0030] That is to say, it is thought probable that, if the rate at which the gas 10 is diffused is intermittently increased, the flow patterns of the currents in the vicinity of the flat membrane are radically altered, and soiling substances on the membrane surface are removed at this point, so that the membrane surface is kept clean.

[0031] It is possible to change the pattern of the rate of flow of the gas in various ways, but experimental results indicate that a method wherein this is increased in short time-period cycles is more effective than one wherein the rate of flow of the gas is increased over long intervals of time.

[0032] In other words, for example, it is more effective to have cycles with increased flow for 6 minutes in 1 hour than to have increased flow for 30 minutes once every 5 hours. Moreover, the size of the gap 6 between a flat membrane module 3

and an adjacent module is an important factor. If this is too wide, soiling of the membrane will progress, and if this is too narrow, this is readily obstructed by foreign matter. Experimental results show that 10-30 mm is optimal.

[0033] Furthermore, the disposition of the diffusion device 9 [*sic*] is also quite an important factor. most preferably, a diffuser member 9, comprising a diffusing pipe or plate, is installed in each gap 6 to the side of the flat membrane module, as shown in FIG. 2.

[0034] By virtue of this method, it is possible to radically disturb the water currents created by the rising bubbles at the surface of each membrane of the flat membrane modules 3 in a reliable manner, so as to effectively prevent membrane soiling. In terms of the type of flat-membrane separation membrane used in the present invention, various types of UF membranes (which is to say ultrafiltration membranes) and MF membranes (which is to say microfiltration membranes) can be used: these may be selected in accordance with the type of reaction and the type of suspension.

[0035] For example, if this is applied to wastewater treatment or water supply treatment, a microfiltration membrane with a pore size of approximately 0.01-1 μm can be used, and if high-level treatment is to be performed, UF membranes with a molecular weight cutoff of approximately 1000-100,000 can be used.

[0036] The device of the present invention is suitable for separation of microbiological suspensions, but it is also suitable for separating formed flock when coagulation agents, such as aluminum sulfate, are added to river water.

Experimental Examples

The performance of the present invention was proved experimentally using the present invention as a device for activated sludge processing of sewage.

[0037] A water tank having a width of 30 cm, a length of 40 cm, and a height of 70 cm was filled with a slurry of MLSS 3500 mg/liter activated sludge (water level 50 cm) and two of the following flat membrane modules were immersed in the perpendicular direction.

[0038] Flat membrane module specifications:
size: 15 x 15 cm^2 MF membrane
membrane pore size: 0.5 μm
spacer: plastic porous body with a pore size of 150 μm (plate)
rate of diffusion: amounts of air blown from the diffuser pipe are increased and decreased in the following cycles.

[0039] Cycles were repeated as follows:
100 liters air/minute for 30 minutes
thereafter, 300 liters of air/minute for 3 minutes
thereafter, reduced to 100 liters of air/minute for 30 minutes.

[0040] Operations were continued for six months under these conditions, and the membrane permeate flux was as shown by line a in FIG. 3. During this experimental period, the membrane was never washed with chemicals.

[0041] Furthermore, line b in the figure indicates results for a case where the rate at which the air was diffused was fixed at 100 liters/minute. It is clear that intermittently increasing and decreasing the amount of air was effective in maintaining high flux.

[0042] Furthermore, as the membrane used as the filter body in the present invention was flat, absolutely no clogging or adherents of suspended solids within the hollow-fiber membrane bundle module was observed, and this was maintenance-free.

[0043]

[Effects of the Invention] (1) There was no adhesion of suspended solids, contaminants, or fiber components on the membrane surface; such was the case with the hollow-fiber membrane method, allowing for maintenance-free operation.

[0044] (2) It was possible to maintain the membrane permeate flux at a stably high value over a long period of time. (3) The flat membrane is simply attached to a spacer and immersed in a tank, so that the device and the manufacture thereof are simple, and the manufacturing costs thereof are low.

[0045] (4) Meanwhile, even in cases where unexpected trouble results in soiling of the membrane and a drop in permeation flux, the flat membrane module can simply be pulled out and easily cleaned with a high-pressure water spray. With the hollow-fiber membrane method, cleaning was not possible without undoing the hollow fibers one by one, which could not be done except by humans and was extremely labor-intensive.

[0046] (5) As the membrane surface is planar, each of the membrane faces can reliably receive the disturbances in flow caused by the bubbles. With hollow-fiber membranes, it would not be possible to provide the disturbance uniformly to the surfaces of the hollow-fiber membranes one by one.

[0047] Consequently, soiling is extremely unlikely to occur.

[Brief Description of the Drawings]

[FIG. 1] This figure serves to describe an example of a membrane separation device of the present invention.

[FIG. 2] This is a perspective view illustrating one example of a filter body used in the present invention.

[FIG. 3] This is a graph showing the results of an experimental example using the device of the present invention.

[FIG. 4] This is a figure for the purpose of describing one example of a conventional membrane separation device.

[Explanation of the Reference Numerals]

1	tank
2	inlet
3	flat membrane module
4	spacer
5	flat UF or MF membrane
6	gap
7	outlet pipe
8	membrane permeate suction pump
9	diffuser
10	gas
11	blower
12	valve
13	blower
21	aeration tank
22	hollow-fiber membrane module
23	diffusion pipe
24	air
25	suction pump

FIG. 1

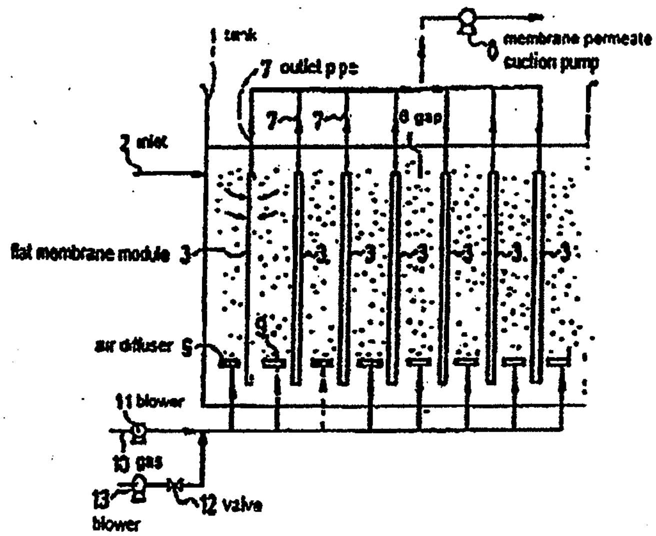

FIG. 2

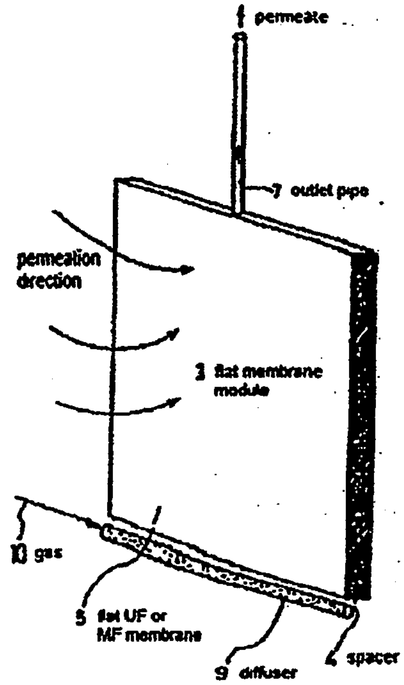

FIG. 3

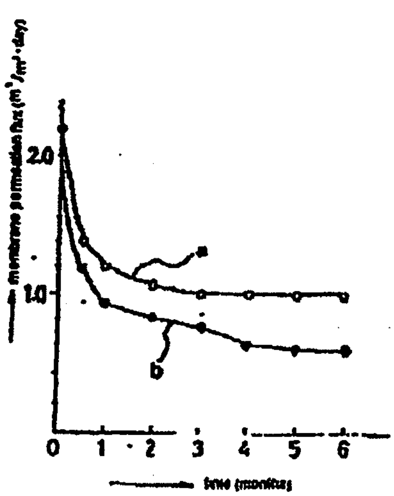

FIG. 4